

THE NEAREST BLACK HOLE

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The goal of this program is to study black holes, both in our Galaxy and in nearby galaxies. We aim to study both 'stellar mass' x-ray binaries containing black holes (both in our Galaxy and in nearby galaxies), and super-massive black holes in nearby galaxies. This program facilitates this study by funding related travel, computer equipment, and partial salary for a post-doc.

PERSONNEL:

This grant continued to provide partial support to Dr. Ben Williams, who will be leaving us after 3 years this coming fall. He has several job offers for new postdocs.

Dr. Manuel Torres will be with us for another 2 years and is partially supported on this program. He continues to work on Galactic BHXN, and will shortly start work on our AO5 M31* Chandra/VLA program.

Dr. Roberto Soria is now at the CfA but now working with Dr. Fabbiano.

TRAVEL:

Trip to Open University, collaborations with Dr. Barnard and Prof. Kolb. Chandra/XMM comparisons of M31 data.

This productive trip resulted in discovery of what may be the first case of a LMXB embedded in a SNR in and external Galaxy. Within the MW the only case of this is SS433/W50. We wrote a Chandra proposal to follow this object up (R3-64). A paper is in prep. There are several other likely cases within M31. It required comparison of Chandra and XMM data to identify these.

TALKS:

Physics Colloquium at Open University, 'The Next Nearest Black Holes'

Discussions with Prof. Fulvio Melia (U of A) and Dr. Lorant Sjouwerman (NRAO) resulted in our planning to organize a 1 day workshop on M31* to be held in conjunction with a workshop on Sgr A* in New Mexico, summer of 2006.

A Possible Detection of M31* with Chandra; Submitted to ApJ, astroph-

Michael R. Garcia, Benjamin F. Williams, Feng Yuan, Albert K. H. Kong, F. A. Primini, P. Barmby, P. Kaaret, and Stephen S. Murray

Two independent sets of Chandra and HST images of the nuclear region of M31 allow registration of X-ray and optical images to $\sim 0.1''$.

This registration shows that none of the bright ($\sim 10^{37}$ ergs) X-ray sources near the nucleus is coincident with the central super-massive black hole, M31*. A 50ks Chandra HRC image shows 2.5σ evidence for a faint (3×10^{35} ergs), apparently resolved source which is consistent with the position of the M31*. The Bondi radius of M31* is $0.9''$, making it one of the few super-massive black holes with a resolvable accretion flow. This large radius and the previous detections of diffuse, X-ray emitting gas in the nuclear region make M31* one of the most secure cases for a radiatively inefficient accretion flow and place some of the most severe constraints on the radiative processes in such a flow.

Discovery of an X-ray Nova in M31; Williams, Garcia et al 2004 ApJ 620 723

We have obtained snapshot images of an X-ray nova in M31 from *Chandra* ACIS-I and the *Hubble Space Telescope* (HST) Advanced Camera for Surveys (ACS). The *Chandra* position of the X-ray nova was $RA=00:44:06.68 \pm 1.74''$, $Dec=+41:12:20.0 \pm 2.31''$. A follow-up *HST* observation 24 days later revealed a source at $RA=00:44:06.81$, $Dec=+41:12:24.0$ that was $B=25.75 \pm 0.05$. This optical source faded to $B=27.1 \pm 0.1$ in 3 months. During this time period, the X-ray flux decayed linearly from $(3.6 \pm 0.2) \times 10^{-4}$ to $< (6.9 \pm 0.09) 10^{-5} \text{ ct cm}^{-2} \text{ s}^{-1}$. The *HST* identification of an optical source in the same region experiencing an obvious drop in brightness in concert with the X-ray nova suggests that this optical source is the counterpart of the X-ray nova. However, the precision of

the X-ray position allows the possibility that the optical source is a nearby variable star. We discuss the implications of both possibilities.

Why are X-Ray Sources in the M31 Bulge So Close to Planetary Nebulae?, Williams, Garcia, McClintock, Kong, 2004 AJ 128 1588

We compare a deep (37 ks) *Chandra* ACIS-S image of the M31 bulge to deep [O~III] Local Group Survey data of the same region. Through precision image alignment using globular cluster X-ray sources, we are able to improve constraints on possible optical/X-ray associations suggested by previous surveys. Our image registration allows us to rule out several emission-line objects, previously suggested to be the optical counterparts of X-ray sources, as true counterparts. At the same time, we find six X-ray sources peculiarly close to strong [O~III] emission-line sources, classified as PNe by previous optical surveys. Our study shows that, while the X-rays are not coming from the same gas as the optical line emission, the chances of these six X-ray sources lying so close to cataloged PNe is only ~1%, suggesting that there is some connection between these [O~III] emitters (possibly PNe) and the X-ray sources. We discuss the possibility that these nebulae are misidentified supernova remnants, and we rule out the possibility that the X-ray sources are ejected X-ray binaries. There is a possibility that some cases involve a PN and an LMXB that occupy the same undetected star cluster. Beyond this unconfirmed possibility, and the statistically unlikely one that the associations are spatial coincidences, we are unable to explain these [O~III]/X-ray associations.

"A Catalog of X-ray Transients in M31", Williams, Garcia, Niak, Kong, Primini, Murray, 2005, in prep.

An X-ray Transient and Optical Counterpart in the M31 Bulge, Williams, Garcia, Kong, Primini, Murray, 2005 ApJ submitted